Insect and Disease Threats Associated with an Oak/Shortleaf Pine Stand Restoration Plan on the Wayne National Forest

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Abstract

The Wayne National Forest requested an assessment of insect and disease risks associated with silviculture treatments proposed for a mixed hardwood/pine forest. The silviculture options were: 1) No Action, 2) Shelterwood Cut, and 3) Clearcut and Planting. Both options 2 and 3 have a goal of regenerating the stand and limiting the species composition to pine/oak/hickory while suppressing invasive plants and reducing less-preferred hardwoods (e.g., beech, red maple, tulip poplar). Forest health concerns found associated with the No Action option included increased susceptibility to associated insects and diseases due to increased tree competition and stand age, while high stand diversity was noted as beneficial in preventing any one damage-causing agent from devastating the stand. Concerns noted for the Clearcut and Planting option were insects that could potentially damage regenerating pine stands. Concerns for damage to residual trees associated with the repeated entries of the shelterwood treatment were addressed. In addition, commonly found insect and disease agents associated with target tree species and invasive plant species treatment options were noted.

Purpose and Need

The Morgantown Field Office (MFO) received a request from the Ironton Ranger District, Wayne National Forest, Ohio, USA, to evaluate a 40-acre timber stand for insect and disease vectors. The request originated from District Forest Management Team Leader Chad Fitton, who is completing a silviculturist license with a harvest prescription for a timber stand. We are assisting with recommendations and considerations of insects and diseases that may impact the shortleaf pine (*Pinus echinata*) and oak (*Quercus* sp.) prescription he has written for stand 10, compartment 407.

Currently, the stand consists of mixed pine and hardwood species. There have been observations of stressed and dying shortleaf pine within the stand. The stressed pines were investigated to determine if the cause was from biotic factors such as insects and diseases or abiotic factors such as soil nutrients or climatic conditions. Understanding these factors will assist in the decision of species regeneration in the stand prescription.

Project Location/Description

The Wayne National Forest is situated in the hills of southeastern Ohio and consists of approximately 250,000 acres of land divided into three units. The project stand (N 38.837876, W -82.540171, figure 1) is located in the Ironton Ranger District, 4.1 miles southeast of Oak Hill. This stand is approximately 40 acres in size and is a hardwood/pine forest type. The overstory is mainly composed of shortleaf pine (*Pinus echinata*), Virginia pine (*Pinus virginiana*), red maple (*Acer rubrum*), yellow poplar (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), and shagbark hickory (*Carya ovata*); shortleaf and Virginia pine comprise approximately half of the overstory trees (figure 2 and figure 3). There are a total of 19 species of trees greater than 6 inches in d.b.h. occurring in the stand. The understory growth (trees <6 inches d.b.h.) consists mainly of red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), American hornbeam (*Carpinus caroliniana*), white oak (*Quercus alba*), black oak (*Quercus velutina*), and hickory (*Carya* sp.).

This stand was once part of an analysis area called the Buckeye project that was cancelled due to public concerns following the NEPA analysis phase. The objective of the silvicultural prescription is to regenerate a shortleaf pine-oak-hickory stand composition.

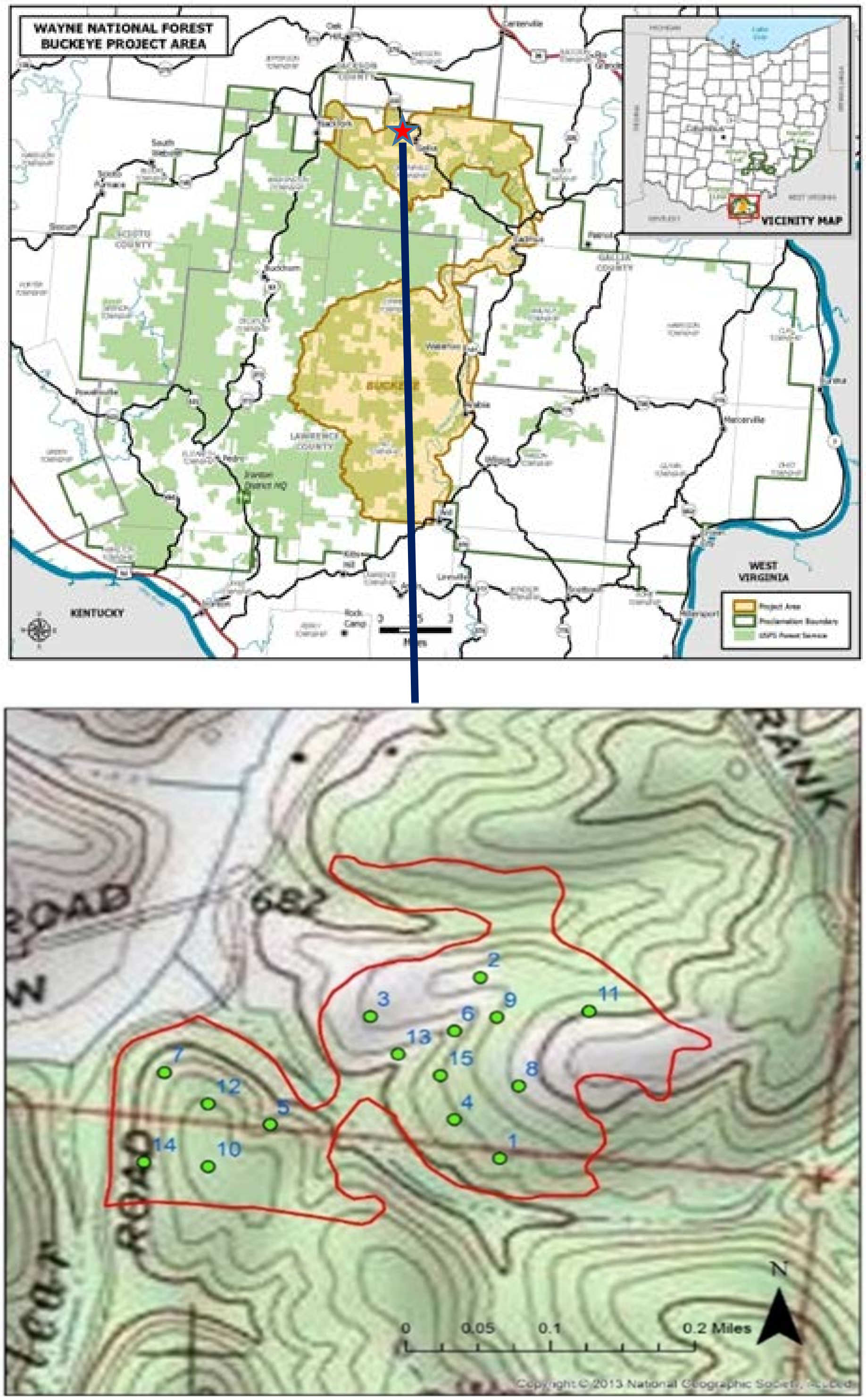

Figure 1. Stand location within the state of Ohio (top) and stand boundary and variable-radius plot centers (bottom).

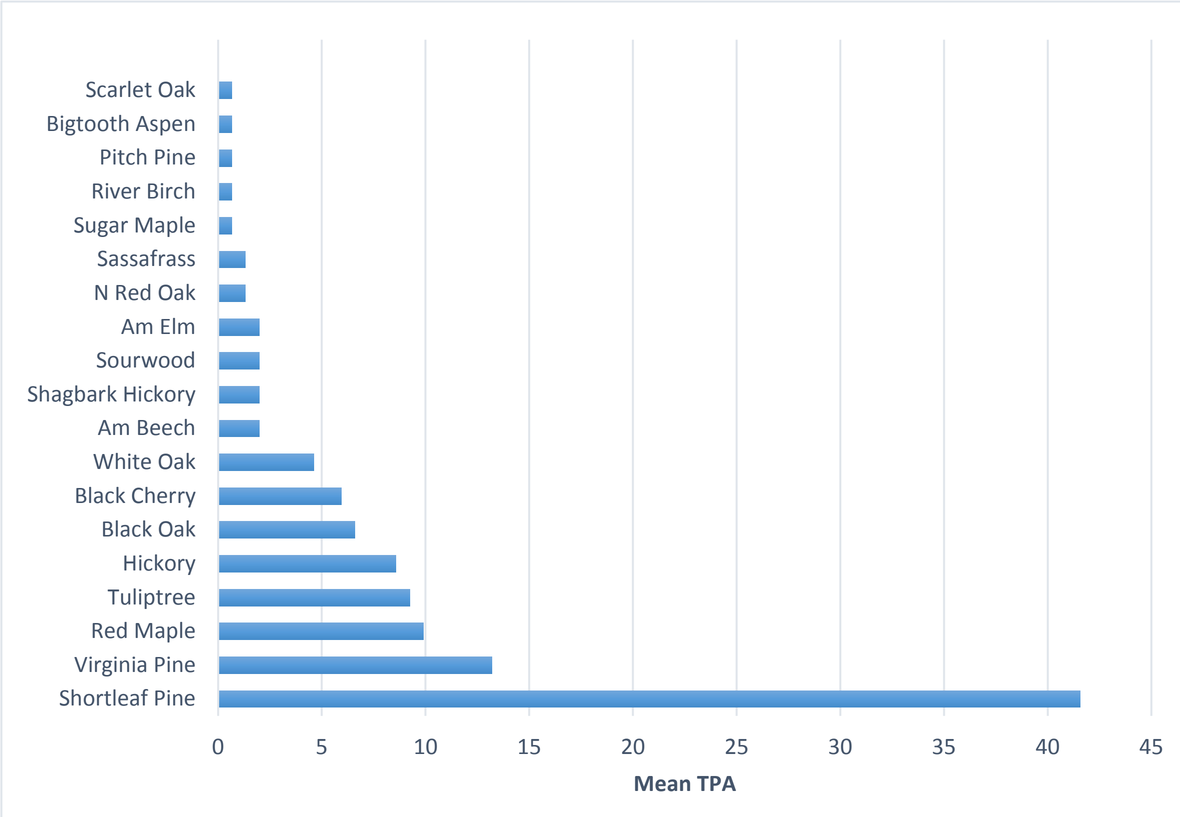

Figure 2. Mean trees per acre (TPA) of trees >6 inches diameter at breast height by species within the proposed treatment stand.

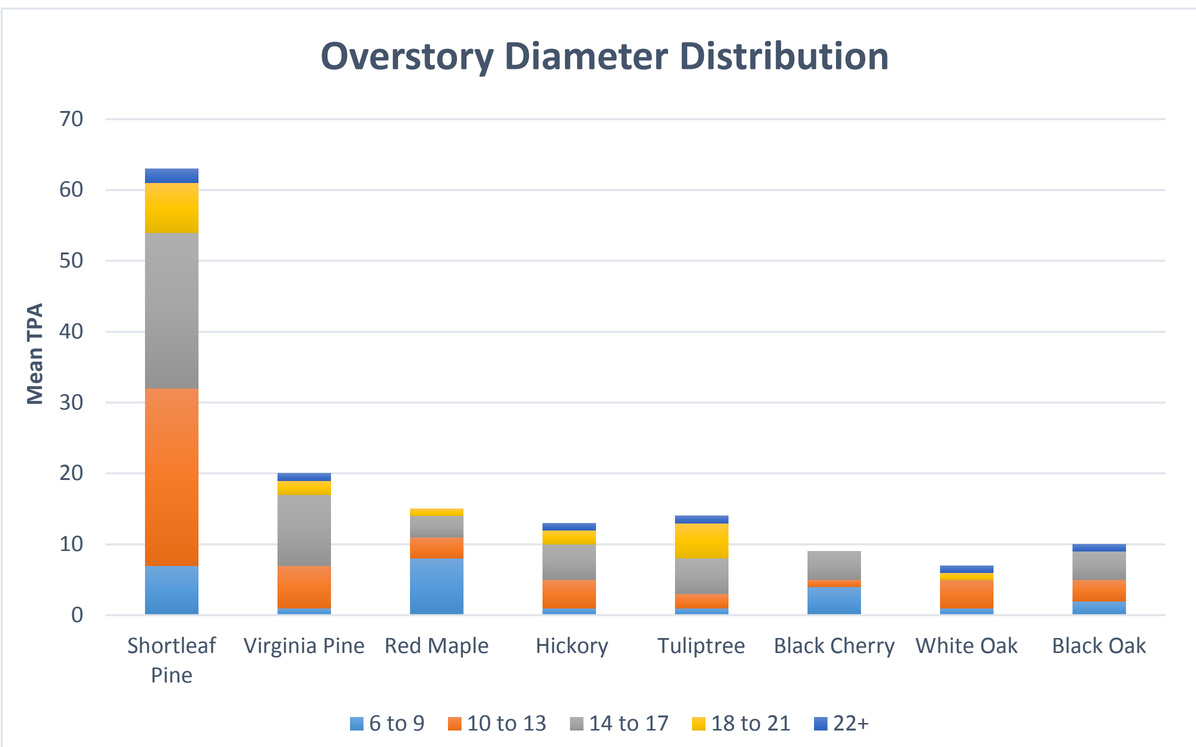

Figure 3. Diameter distribution by 3-inch diameter classes of the most commonly found overstory tree species (>5 trees per acre (TPA)).

Objectives

The objective of this evaluation is to determine the potential insect and disease hazards associated with the silviculture prescription suggested for this stand and the predicted outcome of allowing this stand to develop from its current condition.

Methods

Stand condition data were collected by the Ironton Ranger District during a mid-level assessment conducted in 2008 by an interdisciplinary team to form and initiate a pre-NEPA analysis. Field visits were also conducted by forest health technicians from the MFO on 12 December, 2016. MFO technicians reestablished 15 plot centers from previous stand assessments and established variable radius plots (10 basal area factor).

Plot centers were reestablished using rebar, numbered bronze tags, and stake chasers at the base of the rebar. In each plot, the live crown ratio was measured for shortleaf pine, pitch pine (*Pinus rigida*), and Virginia pine. In addition, four Lindgren funnel traps were placed in proximity to an area where tree mortality had recently occurred. We used the Early Detection Rapid Response protocol to establish these traps. Each of the four Lindgren funnel traps was baited with different lures to attract different bark and wood-boring beetles. Trap 1 was baited with an ultra-high release (UHR) ethanol lure, a general attractant for wood-boring insects. Trap 2 was baited with frontalin and endo-brevicomin, a southern pine beetle attractant. Trap 3 was baited with a three-component *Ips* lure, which is specific to a number of species of pine bark beetles in the genus *Ips*. Finally, trap 4 was baited with alpha-pinene and an ultra-high release (UHR) ethanol lure, another general attractant for wood-boring beetles. These traps were checked periodically from 1 May, 2017, to 16 August, 2017.

A recently dead shortleaf pine was felled and inspected to determine cause of mortality. Bolts collected from the tree were brought to the MFO lab to rear any beetles that may be in the samples. Each 20-inch bolt was split in half and placed in 50-gallon barrels. Barrel openings were covered with a fine mesh Lumite® screen to regulate oxygen and air flow for potential beetle larvae. The barrels were stored in an outdoor rearing shelter and were monitored until the end of the summer of 2017. After monitoring was completed, the bark was stripped and the cambium layer was inspected for signs of deceased larvae or larval activity.

Results/Insect and Disease Implications of Management Alternatives

Alternative 1 – No Action

If a No Action option is chosen, the stand will continue to develop, moving away from a pine-dominated, early seral stand to a species-rich, mixed-hardwood stand with pine decreasing in dominance and red maple becoming more prevalent. As the stand becomes more heavily stocked and tree competition increases, overstory tree mortality may increase, which could be facilitated by insects and diseases.

Many forest insect pests and disease agents have specific host preferences. Species diversity in a stand creates a condition in which the outbreak of an aggressive, tree-killing damage agent will not likely kill all of the trees in a stand. For example, the emerald ash borer is slowly killing all ash trees >1 inch d.b.h., but the impact on the forest as a whole is buffered where ash trees are a minor component of many stand types. In stands with a high component of ash, the impact could be catastrophic.

Invasive Plant Species

If no management action is taken, special consideration should be given for the invasive plants within the stand that may displace native vegetation. Some exotic, invasive plants can grow rapidly, displace native vegetation, and disrupt the structure and function of native ecosystems. In December 2016, two non-native, invasive woody species were observed in the stand: Japanese honeysuckle (*Lonicera japonica*) and multiflora rose (*Rosa multiflora*). It is important to address these species because they are difficult to control once established in the forest. Each of these woody species is aggressively growing, potentially outcompeting new seedlings and other native vegetation for resources and ultimately replacing them in the landscape. Where gaps occur in the canopy, these species take advantage of sunlight and can establish quickly, forming large thickets that are impenetrable to sunlight. Eventually any new tree seedlings can die off due to lack of sufficient sunlight and inability to compete with these aggressive non-natives. Herbicide use and mechanical methods are effective against infestations and protect the native species at the same time. Other non-native, invasive species that could be present in adjacent areas and have the ability to take advantage of openings within the stand could also pose a threat to the diversity of species and regeneration of desired native woody species there.

Invasive Plant Species Control Recommendations

Japanese honeysuckle (figure 4) is a non-native, invasive vine that climbs and attaches itself to saplings and other shrubs, uses them for support, blocks them from sunlight, girdles them, and can kill them. This species can dominate and take over in forests that are in early successional stages or when gaps are created in mature stands. The seeds of this plant are dispersed by birds and small animals and do remain in the seedbank. These vines can block sunlight and eventually kill even mature trees.

Figure 4. Japanese honeysuckle infestation. (Courtesy photo by Chuck Bargeron, University of Georgia, Bugwood.org)

For small patches of Japanese honeysuckle, plants can be hand pulled by holding them close to the ground (which works best when the soil is moist) and pulled up to remove the roots as well. Areas would need to be rechecked to remove new plants if they arise. For larger patches, herbicide application would be necessary at least once from mid-May to mid-September. A second application during the same growing season might be needed for denser populations. Hanging vines can be cut so that they disintegrate naturally, but the base of the plant with its roots must be treated since resprouting will likely occur.

Burning will kill off plants, but regeneration is likely due to the soil seedbank and increased sunlight on the bare ground. Post-treatment monitoring is necessary to detect and treat new infestations.

Multiflora rose (figure 5) is a non-native, invasive, arching shrub that grows vigorously, forms thickets (replacing other native shrub and herbaceous species), and produces large amounts of hips (fruits) that are spread by birds. Hundreds of seeds are produced by one plant and remain in the soil for many years.

Herbicide application should occur from mid-May to mid-September. Denser populations can be mowed repeatedly during the growing season. A combination of the two methods can be very effective. Additionally, cut stumps of the larger stemmed plants (greater than 1 inch diameter) can be painted with

herbicide in the fall when the plant is moving resources to its roots (making sure herbicide doesn't drip down the stem and leach into the soil, possibly affecting other non-target species). This might work well in a natural forest setting so that habitat disturbance is not severe. Herbicide painting can be done when the plant is dormant as well. Burning will curb an infestation, but a soil seedbank may remain and resprouting can occur due to root suckering. Post-treatment monitoring is necessary to detect and treat new infestations.

Figure 5. Multiflora rose growing on the side of a path. (Courtesy photo by Chris Evans, University of Illinois, Bugwood.org)

Insect Pests of Mature Pines

Southern pine beetle (SPB, *Dendroctonus frontalis*) is a destructive forest pest that will attack and kill a wide range of pine species, including shortleaf, Virginia, and pitch pine. SPB has not been confirmed in the stand. The Ironton Ranger District, however, is situated at the northern edge of the current SPB geographic distribution. The northern boundary of the SPB range is dictated by cold winter events and the presence of host trees (Ungerer and others 1999). SPB is not a cold-tolerant species of bark beetle and will experience extensive winter mortality if temperatures drop below -16 °C (3.2 °F) (Ungerer and others 1999). Although these cold temperatures don't occur every year, temperatures lower than -16 °C are not uncommon in this area (four of the last ten years experienced below zero Fahrenheit temperatures in this area as recorded at the RAWS weather station, Dean, OH). These cold events help keep any local SPB populations in check and keep the likelihood of SPB causing mortality in this stand low. If in the future the local climate experiences fewer cold events, populations could increase locally and the high basal areas associated with the No Action option would provide conditions that are more favorable to SPB-caused pine mortality.

The majority of wood-boring beetles recovered from the rearing containers were *Cossonus corticola,* which are typically found in the sapwood of killed pines and are not known to cause tree mortality. Arrowhead borers (*Xylotrechus sagittatus*) were also found; they are common throughout the Eastern United States and are secondary invaders of pine. Twig beetles (*Pityophorus* sp.) emerged from the logs early in the season and are known to feed on the inner bark of pines, but are not known to cause serious injury to the host tree. Only one red turpentine beetle (*Dendroctonus valens*) was found in the rearing container. Red turpentine beetles attack all species of pine within its range, usually attacking trees of reduced vigor, but they can attack apparently healthy trees. Destructive populations may develop in trees disturbed by logging, fire, or land clearing. Because no tree-killing insects were found in the rearing containers, we believe that other abiotic factors contributed to the death of this tree.

No SPB were found in the pheromone-baited traps, another indication that SPB is not currently in the area, and 311 checkered beetles (*Enoclerus rosmarus*) were also found in the traps. Checkered beetles are predators of bark beetles, and high populations could be beneficial for keeping bark beetle populations low. Finally, pales weevils (*Hylobius pales*), a species of concern for young pine stands and addressed in the Alternative 3 section, were also found in our traps.

The live crown ratio (LCR) on our plots ranged from 10% to 40%, and the mean LCR for the plots was 25%. A study by Baker and Shelton (1998) of suppressed southern pines showed a relationship between LCR, d.b.h., and height. Suppressed pines with an LCR >20% exhibited increasing diameter and height

growth rates after a crown release was conducted. With the small crowns observed and increasing stand density associated with the No Action alternative, the pine overstory of this stand can be expected to become increasingly vulnerable to insects and experience poor diameter growth rates. Suppressed pines, or pines with very small crowns, have a reduced ability to photosynthesize, grow wood, or produce the secondary chemicals required to defend themselves against attacking insects.

Insect Pests of Oak and Hickory

There are many insects and diseases that impact oak trees, in this case white and black oak. Because the future management of this stand aims at increasing the oak component, it is important to be aware of these potential problems. Aside from gypsy moth, there are a variety of defoliating and boring insects (table 1) that occasionally become pests that the forest manager should be aware of.

Table 1. Host tree preferences, damage caused, and control techniques of common insect pests of oaks and hickory in the mid-Appalachian region.

Species	Common Name	Damage Type	Preferred Host(s)	Damage Potential	Management Techniques
Croesia semipurpurana (Kearfott)	Oak leaftier	Defoliation	Northern red and scarlet oak	Repeated defoliation usually results in twig and branch dieback, loss of diameter growth, and tree decline	Pesticide sprays
Archips semiferanus (Walker)	Oak leafroller	Defoliation	White and chestnut oak	Repeated defoliation usually results in twig and branch dieback, loss of diameter growth, and tree decline	Pesticide sprays
Agrilus bilineatus (Weber)	Twolined chestnut borer	Branch and tree death	White, scarlet, northern pin, bur, chestnut, northern red, post, black, and live oak	Attacks and kills stressed oaks, commonly oaks stressed by drought, suppression, injury, defoliation, and soil compaction	Maintaining tree vigor, pesticide injections, cultural (e.g., pruning, cut and remove)
Malacosoma disstria Hubner	Forest tent caterpillar	Defoliation	Wide host range of broadleaf trees including oaks	Occasional outbreaks typically last three years and can cause repeated defoliation that leads to some mortality in suppressed trees	Natural predators, a naturally occurring fungus, Polyhedral virus disease, pesticide sprays, Bt
Caliroa quercuscoccineae (Dyar)	Scarlet oak sawfly	Defoliation (skeletonizes leaves)	Scarlet, black, pin, and white oak	Defoliation; not typically associated with tree mortality	Microbial diseases, natural enemies, pesticides
Enaphalodes rufulus (Haldeman)	Red oak borer	Wood degradation	Commonly attacks northern red, black, and scarlet oak. Less commonly damaged are white, post, pin, bur, overcup, and laurel oak.	Although trees are not typically killed, this insect attacks live trees and larvae burrow into xylem, causing damage to potential lumber	Maintaining good tree vigor
Scolytus quadrispinosus Say	Hickory bark beetle	Top killing; can kill stressed trees	Pecan and hickories	Typical of most bark beetles, it will mostly only kill damaged or extremely stressed trees	Promote tree vigor through stand thinning, pesticides

Gypsy Moth

The susceptibility of a stand to gypsy moth (*Lymantria dispar*) is defined as the probability of defoliation by the gypsy moth given its presence. Characteristics of a susceptible stand include a large number of favored food species, abundant refuges for larvae, and sparse litter protection and unfavorable habitat for small mammal predators. Herrick and Gansner (1986) outlined a way to rate stand susceptibility using species composition, tree size, and average tree condition. Species composition is the most important factor in determining the susceptibility of a stand. Certain species are immune or resistant to larval defoliation (e.g., red maple, black cherry, yellow poplar, and pitch pine) while others are more susceptible (e.g., oak species, paper birch, and basswood). A stand with a high percentage of susceptible species, such as black oak, chestnut oak, scarlet oak, northern red oak, and white oak, has a higher probability of heavy defoliation.

A gypsy moth infestation in this mixed hardwood/pine stand is a concern; however, at the moment the pest is not in the area, and the relatively low proportion of oaks in this stand makes the probability of having extensive gypsy moth defoliation extremely low. Although gypsy moth has a wide host range, high levels of defoliation are mainly found in oak-dominated stands, especially those with black and chestnut oak (Herrick and Gansner 1986). Even if gypsy moth was found in this area, the current stand has a light gypsy moth defoliation potential because oaks make up far less than 50% of the stand (as rated by the system presented in Herrick and Gansner 1986).

Currently, this stand is just outside of the current geographical range of gypsy moth. It is not clear exactly how soon the location will become infested with gypsy moth because there is an active program established in this area to "slow the spread" of gypsy moth, which primarily utilizes the release of mating disruption pheromones for this purpose. According to recent data, gypsy moth spread has generally been 5.3 or 3.3 miles per year over the last 28 years. However, the closest infestation in Ohio to the stand of concern is 128 km (79 miles) away and has had an average spread of -6.45 km (-4.03 miles) per year over the past 17 years (personal communications, David Adkins, Ohio Department of Agriculture Gypsy Moth Program Manager). Considering the presence of a successful and active gypsy moth management program and the negative spread experienced in Ohio in the recent past, gypsy moth is not likely to spread into this stand in the near future, but could at some point.

Tree Diseases of Pines

There are many tree diseases of pines including Heterobasidion root disease, littleleaf disease, pitch canker, needle cast, and Hypoxylon canker.

Littleleaf disease is an important root disease in shortleaf pine. It is associated with a commonly found fungus, *Phytophthora cinnamomi*, and is associated with clay soils. Trees infected with littleleaf disease have sparse foliage, short needles, tufted upturned groups of needles, and yellow foliage, and are killed in 3-10 years. Littleleaf affects trees that are more than 20 years old. Soil samples were collected from this stand and cultured using a forest health protection standard sampling and culturing protocol. The soil samples were collected in October 2016 and were baited using rhododendron leaves and left to culture over several weeks in a *Phytophthora*-specific media. The results from this test were negative for *P. cinnamomi* fungal spores. This test has a high success rate of *Phytophthora* detection; however, no test is 100% accurate in great part due to varying conditions of soil temperature and distribution of pathogens on the site.

Although there is not a high level of incidence of this disease in southeastern Ohio, Heterobasidion root disease (HRD) has been found infecting pines in two counties in Ohio (Lawrence and Hocking Counties). HRD is a disease caused by the fungal pathogen *Heterobasidion irregulare* that decays the roots of

numerous species of pines. In the Northeast, it can infect red, jack, white, shortleaf, Virginia, and pitch pine. This disease causes tree mortality and can be spread through root contacts and by spores. Spores can travel great distances on the wind and cause new areas of infection when they land on fresh tree wounds or recently cut stumps. Once the fungus gets into roots of one tree or stump, it slowly spreads through roots to nearby trees, causing an area of mortality that slowly expands and remains on a site as long as there are host trees to infect. Although spores can travel large distances, distance to the closest area of HRD infection is used to rate the hazard of infection and trigger management activities. Pine stands that are going to have thinning or harvesting activities of pines, aim to retain pine on the site, and are within 6 miles of a known HRD pocket should be considered for preventative treatments. The main treatment to prevent infections and the spread of HRD is to treat freshly cut stumps with a fungicide as part of harvesting activities.

Tree Diseases of Oaks
Oak wilt (*Ceratocystis fagacearum*) is a fungal pathogen that causes wilt in a variety of oak species and kills thousands of oaks each year. Oak wilt is spread in two ways: by spores that are carried on the bodies of Nitidulid beetles (commonly known as sap beetles) that are attracted to the sap exuded from fresh wounds on healthy trees, and through root grafts from one infected tree to adjacent trees. There are many sap beetles associated with oaks, but those thought to vector oak wilt are the species *Colopterus truncatus*, *Colopterus semitectus*, *Carpophilus sayi*, and *Epuraea corticina*. Tree species in the white oak group are moderately resistant and, when infected, can be killed over a period of several years. Species in the red oak group are generally more susceptible, with some trees being killed by oak wilt in as few as 3 weeks after infection. Oak species found to have been killed by oak wilt include black oak (*Quercus velutina*), bur oak (*Q. macrocarpa*), northern pin oak (*Q. ellipsoidalis*), northern red oak (*Q. rubra*), white oak (*Q. alba*), blackjack oak (*Q. marilandica*), scrub live oak (*Q. fusiformis*), Shumard oak (*Q. shumardii*), southern red oak (*Q. falcata*), Texas live oak (*Q. virginiana*), and Texas red oak (*Q. buckleyi*). Root grafts do not commonly occur between trees of different oak species groups, and species diversity within stands can help retard local spread and limit the impact of this pathogen.

Management techniques for oak wilt include avoidance of injuring trees, removal of infected trees, disruption of root connections between trees, and fungicides. Fresh injuries can be treated with tree paint to prevent sap from building up on the wound and attracting sap beetles. Disruption of root contacts can involve using trenching equipment or a vibratory plow and, in cases where these methods are not practical, infected trees can be felled and the stump extracted. Fungicides can be used to protect trees from infection and are injected into high-value trees that are at imminent threat of infection. In addition, when infected trees are cut, the cut trees should be treated by debarking, chipping, or splitting and drying the wood.

Alternative 2 – Shelterwood Alternative

The shelterwood alternative consists of a long series of site preparation, harvest, and post-harvest management activities. The site prep treatments consist of prescribed burning and herbicide treatment of undesirable herbaceous plants and hardwood trees. A number of tree harvests will be conducted over a 25-year period, with a shelterwood cut in year 4, a seed-tree cut in year 14, and a precommercial thinning in year 24. An additional planting treatment will be conducted in the year following the shelterwood cut as needed. The purpose of this alternative is to regenerate the stand to a specific pine/oak/hickory composition with a natural regeneration method.

Initial Shelterwood Stand
After the first round of burning, herbicide treatment, and harvesting, a stand with a low density of overstory trees and a seedling understory of desired tree species should occupy the site. If these treatments are conducted with care, the overstory trees should benefit from a short period of release and reduced competition for resources. Care should be taken to avoid excessive scorch, mechanical damage, and soil compaction because they leave these "leave trees" vulnerable to insect and disease agents. Pines with high levels of scorch (e.g., 90% needle loss) can sometimes recover and survive, but most often become more easily killed by bark beetles as limited photosynthetic capacity limits the trees' ability to make defensive chemicals. Damaged trees are more likely to be attacked by both SPB and *Ips* spp. Heavily fire-damaged pine trees are more susceptible to SPB. Mechanical wounds can attract *Ips* and also serve as an entry point for fungal pathogens such as heart rots.

As the cohort of pine seedlings starts to develop, some insects can negatively impact young pine stands and have the potential to cause unacceptable levels of damage. These damaging agents are discussed in the Alternative 3 section.

Alternative 3 – Clearcut and Planting Alternative

The purpose of this treatment option is to regenerate a pine/oak/hickory stand through the use of a clearcut, a prescribed burn to prepare the site, planting, and subsequent precommercial thinning. The main forest health concerns of this treatment option are dominated by insects that prefer young pines and pole-sized stands. Although leaf and needle pathogens can impact young stands, most tree pathogens are associated with older trees (e.g., cankers, root rots, heart rots) that have been damaged or injured, which often provides pathways for pathogens.

Insect Pests of Plantation/Regenerating Pine
There are many insect and disease pests associated with pines, many of which specifically target young, regenerating pine and pine plantations. Pine seedlings can be damaged, deformed, and sometimes killed by a variety of insects, including pine weevils (e.g. *Hylobius* sp., *Pissodes* sp.), Nantucket tip moth (*Rhyacionia frustrana*), and pine webworm (*Pococera robustella*). Our insect traps within the stand captured pales weevil (*Hylobius pales*), which is the most serious pest of pine seedlings in the eastern half of the United States (Johnson and Lyon 1991).The adult weevil feeds on the bark and twig of small branches, often girdling and killing them. In seedlings, this girdling can take place on the root collar and kill the seedling. Adult beetles lay eggs in the root collar of recently cut stumps or stressed trees, and the larvae feed in the inner bark of the root collar. The least expensive management technique for pales weevil is to delay planting at least 9 to 12 months after harvest. The adult weevils are attracted to the resin of the freshly cut pines, and delaying planting will allow the stumps to "age" and cause them to become less attractive to the adult weevils. Insecticides may also be applied to seedlings to prevent damage. Your local state forest health or extension specialist should be consulted for information on insecticides approved for use for pales weevils in your state. Because this clearcut prescription calls for late summer burning of the site approximately one year post harvesting and planting the spring following the burning, the time between harvest and planting (approximately 1.5 years) and the potential damage to the pine stumps caused by the prescribed fire should greatly reduce the hazard of pales weevil.

Nantucket tip moth is also a pest of pine plantations. The larvae of this moth feed on new growth and bore into the shoots of trees during their first 5 years or until trees reach 12 feet in height. Their feeding kills shoots and causes excessive branching, stem deformity, and stunted growth. Excessive herbaceous weed control is thought to eliminate habitat of natural predators, causing conditions favorable to Nantucket tip

moth. Insecticides can also be sprayed onto foliage to kill this pest. Information on currently registered pesticides in your state can be found by consulting your state forest health specialist.

Bark Beetles

Pine engraver beetles in the *Ips* genus (e.g., *Ips avulsus*, *I. calligraphus*, and *I. grandicollis*) are thought of as secondary pests of pines (typically not killers of healthy trees) but can sometimes cause extensive mortality when trees are stressed by drought or excessive tree competition. *Ips* typically attack weakened trees, recently felled trees, and logging slash. After logging operations when large amounts of slash remain or after disturbances that cause extensive tree damage (e.g. lightning storms, ice storms, tornados, or wildfire), *Ips* populations may build up and, when conditions are conducive (drought and high inter-tree competition), cause extensive mortality in live, standing pine trees. *Ips* often top kill mature trees and kill pines in dense, pole-sized stands. *Ips* can also build up following forestry activities, such as prescribed burns that get too hot and kill or weaken pines, or in thinning operations that compact soils, wound trees, and leave large amounts of branches and cull logs.

Ips preventative strategies in forest stands include:

- Planting species that are appropriate to the site
- Thinning dense, overstocked stands
- Conducting prescribed burns or other treatments to control competing understory vegetation
- Removing and/or salvaging damaged, declining, or recently dead trees
- Avoiding damage to the residual stand when conducting management operations
- Lopping and scattering or removing logging slash

SPB should not present a threat to a young pine/oak/hickory stand. This stand is at the edge of the geographical range of SPB (figure 6) in an area that has not historically experienced outbreak populations and extensive SPB-caused mortality. In addition, high-hazard stands are heavily stocked, pine-dominated stands with most stems in the small-sawlog size class. It should be decades until the stand reaches those stand conditions, and managing stand density can greatly reduce SPB hazard.

Figure 6. The geographical range of southern pine beetle. (Map from The Southern Pine Beetle, Thatcher and others, eds.)

Discussion

There are a variety of insect and disease agents in this area associated with the tree species currently found in this stand. As this stand gets older, it can be expected that various damage-causing agents may kill trees, but high species diversity will make this stand less likely to be extensively damaged by any one organism. Retaining some level of diversity while maintaining individual tree and stand vigor and resiliency should be the overall goal.

One of the biggest challenges will be managing invasive plants and competing vegetation. Managing invasive plants is labor intensive since it often requires repeated treatments over several years. In the case of this stand, if invasive species can be reduced, then prescribed fire can be more effectively used to control fuels buildup and competing vegetation.

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